A STUDY ON
E TREATED WOOD ASSEMBLY
ENTIAL DETERIORATION OF
ASSEMBLY ELEMENTS

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Date: September 23, 1991

MOH project number:

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Terms of Reference 1
1.2 Scope 1
1.3 Sources Contacted 1
1.4 Background 2
.1 General
.2 Kiln Temperature
.3 Chemical effects
Figures 1 to 3 3
.4 Temperature & Relative Humidity effects 4

2.0 DISCUSSION AND CONCLUSIONS 4
2.1 General
2.2 Elevated Temperatures of Roof sheathing 5

3.0 STANDARDS 5

3.1 IN THE USA
3.2 IN CANADA

4.0 SUGGESTED MOH REQUIREMENTS 6

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FIRE TREATED WOOD ASSEMBLY
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1.0 INTRODUCTION

1.1 Terms of Reference

T.Ibronyi Consulting Architect was requested by the Technical Support Services Branch Ministry of Housing to evaluate the effect of fire retardant chemicals on the structural integrity of wood members on long term basis in Ontario's climate.

1.2 SCOPE

The study includes the following :

.1 Review the literature on the subject provided by the Technical Support Services Branch.

.2 Review other literature on the subject available in technical libraries.

.3 Contact the prime authors of the studies/articles to gather information.

.4 Contact fire retardant manufacturers in Canada and in the USA.

.5 Report on the investigation with recommendation to reject/validate the long term suitability of fire retardant chemicals for the Ontario climate and identify products which are not suitable.

.6 Information on FR products manufactured in Canada (with parent companies in US) together with limitations on the use and suggestions for methods of application.

1.3 SOURCES CONTACTED

Thomas Ibronyi Architect has contacted research and trade organizations in Canada and US, CSA, IRC and National Building Code sources,trade organizations representing the lumber and plywood industry as well as the pressure treating and preservative manufacturing industry. Building commissioners in the Metro area were

also contacted asking their views on the use of FR treated lumber and plywood.

1.4 BACKGROUND

.1 General

Over the last 4 to 6 years a substantial number of failures have been reported in the USA in multifamily dwellings an nonresidential commercial buildings that have used FR (fire retardant) treated plywood as roof sheathing (APA,1989).It became apparent that some FR formulations are undergoing thermal decomposition due to elevated temperatures induced by solar radiation.It appears that other formulations are not experiencing this same thermal induced degradation.

.2 Kiln Temperature

Based on current research in the USA,it has been established that initial kiln temperature and after treatment kiln temperature are significant factors in the reduction of strength of FR plywood.The American Wood Preservers Association (AWPA) Standards C-20 and C-27 require that the kiln temperature after treatment be limited to less than 160° F (71° C) until the average moisture content of the FR treated material is below 25 % (AWPA 1990a,b). The US Forest Products Laboratory recommends 15% MC for plywood and 19% MC for lumber.

It has been established by US researchers that most FR treatments initially reduce strength from between 10 to 20% and that the magnitude of these reductions varies with the FR treatment and with the property being considered.Researchers have found that the temperature used in kiln drying FR lumber and plywood after treatment is one of the factors most responsible for the magnitude of these strength reductions in FR treated material.

.3 Chemical Effects

Research has shown that monoammonium phosphate (MAP)and phosphoric acid (PA) inorganic salts were the major chemical component used in the FR treated plywood that have experienced thermal induced roof sheathing failure The cause of strength degrade is acid hydrolysis of the carbohydrates of the wood fibers. Not all formulations experienced the same thermal induced degradation, those which did experience, turn a dark brown with a dry rotted-like appearance, crumble easily when abraded,and often exhibit excessive cross-grain checking. Figure 1 shows that PA and MAP have significantly greater effects than either organic salt.

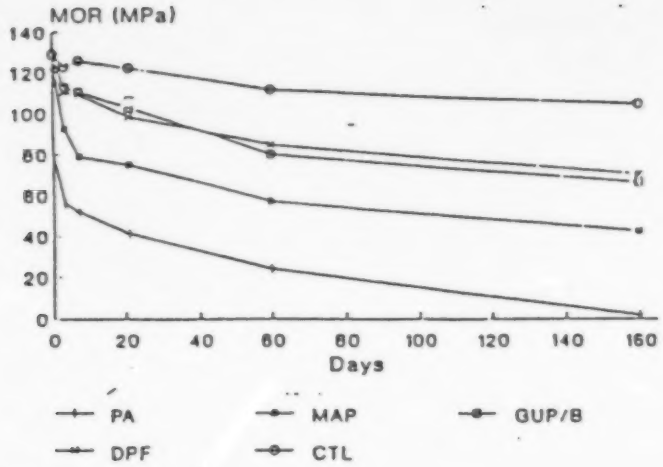


Figure 1. Effects of four fire retardants on bending strength of 16- by 35- by 305-mm clearwood specimens exposed to steady-state exposure at 82°C (180°F) and 50% RH (CTL = untreated; PA = phosphoric acid; MAP = monoammonium phosphate; GUP = guanylurea phosphate; DPF = dicyandiamide–phosphoric acid–formaldehyde).

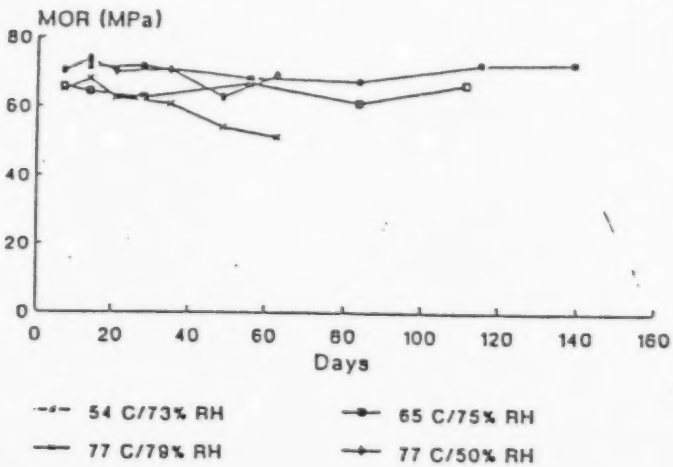
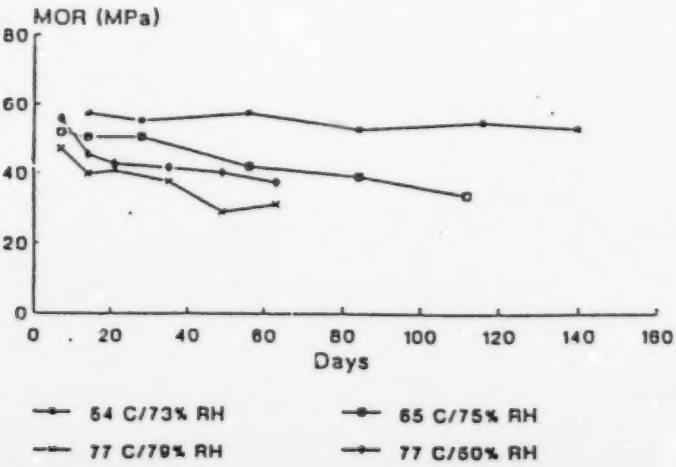


Figure 2. Effect of exposure to various temperatures on modulus of rupture (MOR) of untreated plywood.



.4 Temperature and Relative Humidity (RH) effects

As exposure temperature,relative humidity,and duration increase, mechanical properties of FR treated plywood and lumber are progressively reduced.The influence of these variables on bending strength are shown on Fig 1 Effect of exposure to various temperatures on modulus of rupture(MOR) of untreated plywood shown on Fig 2,on monoammonium phosphate (MOR) treated plywood on Fig.3

From these data it is apparent that:

.1 Before exposure to elevated temperatures,the MAP treatment process causes an initial reduction in strength compared to untreated plywood.

.2 The rate of strength degradation of untreated and MAP treated plywood increases as exposure temperature increases.

.3 The rate of strength degradation of untreated and MAP treated plywood increases as relative humidity increases.

.4 The rate of change over time of exposure in bending strength appears constant for any treatment-temperature combination.

2.0 DISCUSSION AND CONCLUSIONS

2.1 GENERAL

There are two major suppliers of FR chemical products in Ontario, Hickson Corp with parent company in US under the same name and Timber Specialties with a parent company in the US under the name of Osmosis.Both claim that their product does not contain MAP or PA and do not cause degradation. Only Hickson has forwarded literature to explain their "Dricon" product and its properties.

So far there is no reported failure in Canada due to FR treated plywood or lumber according to the sources I have contacted .The reason for that appears to be that there is a very small volume of FR treated lumber and plywood used in Ontario and that there is no financial benefit for small companies to enter the FR chemical manufacturing business. There are several pressure treating companies in Ontario which use the chemicals of the above mentioned companies. It appears to be important to pay special attention to the after treatment kiln drying temperature.

2.2 Elevated Temperatures of Roof sheathing

The temperature of the plywood sheathing is greatly influenced by the colour of shingles.Dark coloured shingles have a much higher absorption rate of solar short and long wave radiation than white or very light coloured shingles. In Ontario in July,under cloudless sky the temperature of the plywood covered with dark brown shingles may rise to 75°C(167°F) whereas the same plywood sheathing covered with off-white or light coloured shingles would be exposed to only 53°C (127°F) temperature. The limit of permanent thermal stability for FR treated material is assumed to be close to 54.5° C(130°F).

3.0 STANDARDS

3.1 In the USA

The American Wood Preservers Association (AWPA) standards C-20 for FR treated lumber,and C-27 for FR treated plywood and ASTM E-84(ASTM,1989) deal with chemical formulation and post treatment drying temperatures employed in developing the original certification.

Most US FR formulators/treaters are currently testing their proprietary FR treatments using a draft test protocol,developed by a joint plywood industry/treating industry/USDA Forest Service,Forest Products Laboratory task group.This draft test protocol provides a standardized testing methodology that quantifies the relative performance of proprietary commercial FR treatments where exposure to elevated temperatures is expected.This protocol has recently been submitted to ASTM for consideration as a consensus standard.

3.2 In Canada

The "Wood Design Manual" in part 11 deals with fire treatment of wood and refers to CAN/CSA-086.1-M-89 Engineering Design in Wood regarding the treatment factors to be applied to the strength properties of wood products.

The testing method for flame spread rating is covered by CAN/ULC-S102-M88. The fire retardant treatment of plywood by pressure processes is dealt with by CAN/CSA-080.27-M89.

None of the above standards go into the specifics of exposure to elevated temperatures or to the testing of proprietary FR treatments. For these aspects of FR treated lumber and plywood reference should be made to the standards and draft test protocol mentioned under para .1.

4.0 SUGGESTED MOH REQUIREMENTS

.1 For fire retardant treated lumber and plywood comply with the requirements of The WOOD DESIGN MANUAL part 11 and with CAN/CSA-086.1-M89, CAN/ULC-S102-M88 and CAN/CSA-080.27-M89, with US AWPA standards C-20 and C-27, ASTM E84 (ASTM,1989) as well as the draft protocol developed by a joint plywood industry/ treating industry/ USDA Forest Products Laboratory task group.

.2 Fire treated wood must be type A product as defined by the American Wood Preservers Association (AWPA) and must conform to ASTM Standard D3201 at 92% RH.

.3 Provide warranty from the FR formulator/treater attesting to the suitability of the FR treated material for the intended use.

.4 Provide certificate and printed information on the following:

.1 initial effects of FR formulation on wood strength, wood stiffness, and fastener corrosion.

.2 information whether the FR treated material has been tested at elevated temperature according to the Draft Protocol by the industry/USDA Forest Products Laboratory task group.

.3 information whether an approved third party inspection agency has certified compliance with chemical formulation and post treatment drying temperatures employed.

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